

Amendments to the Claims

This listing of claims will replace all prior versions and/or listings of claims in the application.

Listing of Claims:

1-2116. (cancelled)

2117. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters to at least a portion of the formation;

allowing the heat to transfer from the one or more heaters to a part of the formation;

controlling the heat such that an average heating rate of the part is less than about 1 °C per day in a pyrolysis temperature range of about 270 °C to about 400 °C;

wherein the part is heated in a reducing environment during at least some of the time that the part is being heated; and

producing a mixture from the formation.

2118. (original): The method of claim 2117, wherein the one or more heaters comprise at least two heaters, and wherein controlled superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons within the part of the formation.

2119. (original): The method of claim 2117, further comprising maintaining a temperature within the part within the pyrolysis temperature range.

2120. (original): The method of claim 2117, wherein at least one of the one or more heaters comprises an electrical heater.

2121. (original): The method of claim 2117, wherein at least one of the one or more heaters comprises a surface burner.

2122. (original): The method of claim 2117, wherein at least one of the one or more heaters comprises a flameless distributed combustor.

2123. (original): The method of claim 2117, wherein at least one of the one or more heaters comprises a natural distributed combustor.

2124. (original): The method of claim 2117, further comprising controlling a pressure and a temperature within at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2125. (cancelled)

2126. (currently amended): The method of claim 2117, wherein providing heat from the one or more heaters to at least the portion of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is less than about $1\text{ }^\circ\text{C/day}$ ~~$10\text{ }^\circ\text{C/day}$~~ .

2127. (original): The method of claim 2117, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2128. (previously presented): The method of claim 2117, wherein providing heat from one or more of the heaters increases a thermal conductivity of at least a portion of the part to greater than about $0.5\text{ W/(m }^\circ\text{C)}$.

2129. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2130. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2131. (original): The method of claim 2117, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2132. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2133. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2134. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2135. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2136. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2137. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2138. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2139. (original): The method of claim 2117, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2140. (previously presented): The method of claim 2117, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

2141. (original): The method of claim 2117, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2142. (original): The method of claim 2117, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2143. (previously presented): The method of claim 2117, further comprising controlling a pressure within at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2144. (original): The method of claim 2117, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ within the mixture is greater than about 0.5 bar.

2145. (original): The method of claim 2144, wherein the partial pressure of H₂ within the mixture is measured when the mixture is at a production well.

2146. (original): The method of claim 2117, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2147. (previously presented): The method of claim 2117, further comprising controlling formation conditions by recirculating a portion of hydrogen (H₂) from the mixture into the formation.

2148. (previously presented): The method of claim 2117, further comprising:
providing hydrogen (H₂) to the heated part to hydrogenate hydrocarbons within the part;
and
heating a portion of the part with heat from hydrogenation.

2149. (previously presented): The method of claim 2117, further comprising:
producing hydrogen (H₂) and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least some of the produced hydrogen.

2150. (previously presented): The method of claim 2117, wherein allowing the heat to transfer increases a permeability of a majority of the part to greater than about 100 millidarcy.

2151. (previously presented): The method of claim 2117, wherein allowing the heat to transfer increases a permeability of a majority of the part such that the permeability of the majority of the part of the formation is substantially uniform.

2152. (original): The method of claim 2117, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

2153. (previously presented): The method of claim 2117, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

2154. (previously presented): The method of claim 2117, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

2155. (previously presented): The method of claim 2117, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2156. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

heating a first section of the formation to produce a mixture from the formation;

heating a second section of the formation;

controlling the heat such that an average heating rate of the first section or the second section is less than about 1 °C per day in a pyrolysis temperature range of about 270 °C to about 400 °C; and

recirculating a portion of the produced mixture from the first section into the second section of the formation to provide a reducing environment within the second section of the formation.

2157. (previously presented): The method of claim 2156, further comprising maintaining a temperature within the first section or the second section within the pyrolysis temperature range.

2158. (previously presented): The method of claim 2156, wherein heating the first section or the second section comprises heating with at least one electrical heater.

2159. (previously presented): The method of claim 2156, wherein heating the first section or the second section comprises heating with at least one surface burner.

2160. (previously presented): The method of claim 2156, wherein heating the first section or the second section comprises heating with at least one flameless distributed combustor.

2161. (previously presented): The method of claim 2156, wherein heating the first section or the second section comprises heating with at least one natural distributed combustor.

2162. (previously presented): The method of claim 2156, further comprising controlling a pressure and a temperature within at least a majority of the first section or the second section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2163. (cancelled)

2164. (currently amended): The method of claim 2156, wherein heating the first section or the

second section comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is less than about 1 °C/day~~10 °C/day~~.

2165. (previously presented): The method of claim 2156, wherein heating the first section or the second section comprises transferring heat substantially by conduction.

2166. (previously presented): The method of claim 2156, wherein heating the first section or the second section increases a thermal conductivity of at least a portion of the first section or the second section to greater than about 0.5 W/(m °C).

2167. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2168. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2169. (original): The method of claim 2156, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2170. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2171. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2172. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2173. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2174. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2175. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2176. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2177. (original): The method of claim 2156, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2178. (previously presented): The method of claim 2156, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises hydrogen (H_2), wherein the hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and 1 atmosphere absolute pressure, and wherein the hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and 1 atmosphere absolute pressure.

2179. (original): The method of claim 2156, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2180. (original): The method of claim 2156, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2181. (previously presented): The method of claim 2156, further comprising controlling a pressure within at least a majority of the first section or the second section of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2182. (original): The method of claim 2156, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H_2 within the mixture is greater than about 0.5 bar.

2183. (original): The method of claim 2182, wherein the partial pressure of H_2 within the mixture is measured when the mixture is at a production well.

2184. (original): The method of claim 2156, further comprising altering a pressure within the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2185. (previously presented): The method of claim 2156, further comprising:

providing hydrogen (H₂) to the first section or the second section to hydrogenate hydrocarbons within the first or second section; and
heating a portion of the first section or the second section with heat from hydrogenation.

2186. (previously presented): The method of claim 2156, further comprising:
producing hydrogen (H₂) and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least some of the produced hydrogen.

2187. (previously presented): The method of claim 2156, wherein heating the first section or the second section increases a permeability of a majority of the first section or the second section to greater than about 100 millidarcy.

2188. (previously presented): The method of claim 2156, wherein heating the first section or the second section increases a permeability of a majority of the first section or the second section such that the permeability of the majority of the first section or the second section is substantially uniform.

2189. (original): The method of claim 2156, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

2190. (previously presented): The method of claim 2156, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

2191. (previously presented): The method of claim 2156, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

2192. (previously presented): The method of claim 2156, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2193-5395. (cancelled)

5396. (previously presented): The method of claim 2153, wherein at least about 20 heaters are disposed in the formation for each production well.

5397. (previously presented): The method of claim 2190, wherein at least about 20 heaters are disposed in the formation for each production well.

5398. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

- heating a first section of the formation to produce a mixture from the formation;

- heating a second section of the formation;

- controlling a pressure and a temperature within at least a majority of the first section or the second section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure; and

- introducing a portion of the produced mixture from the first section into the second section of the formation to provide a reducing environment within the second section of the formation.

5399. (previously presented): The method of claim 5398, further comprising controlling the heat such that an average heating rate of the first section or the second section is less than about 1 °C per day in a pyrolysis temperature range of about 270 °C to about 400 °C.

5400. (previously presented): The method of claim 5398, wherein the portion of the produced mixture introduced to the second section comprises molecular hydrogen.

5401. (previously presented): The method of claim 5398, wherein heating the first section or the second section comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons within the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

5402. (previously presented): The method of claim 5398, wherein heating the first section or the second section increases a permeability of a majority of the first section or the second section such that the permeability of the majority of the first section or the second section is substantially uniform.